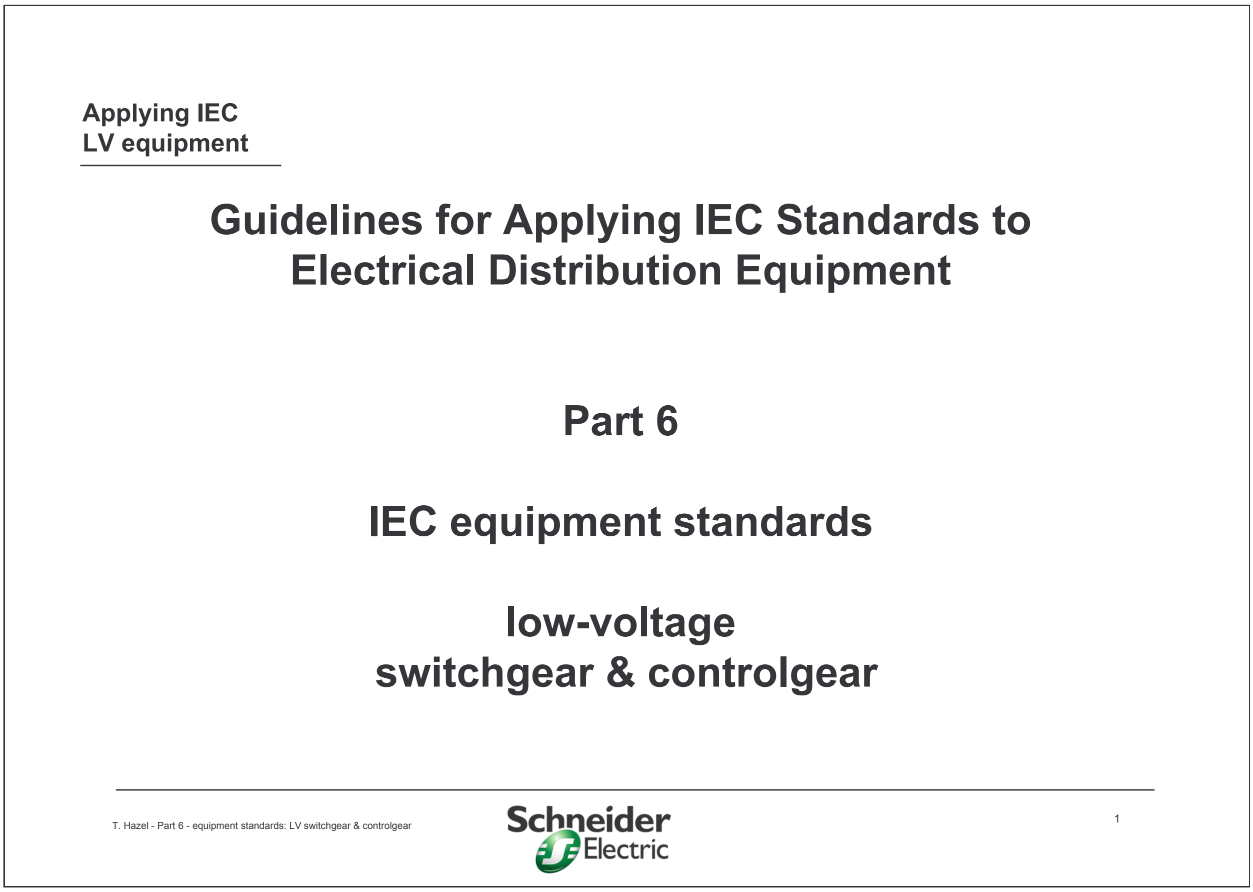


Guidelines for Applying IEC Standards to Electrical Distribution Equipment

Part 6

IEC equipment standards

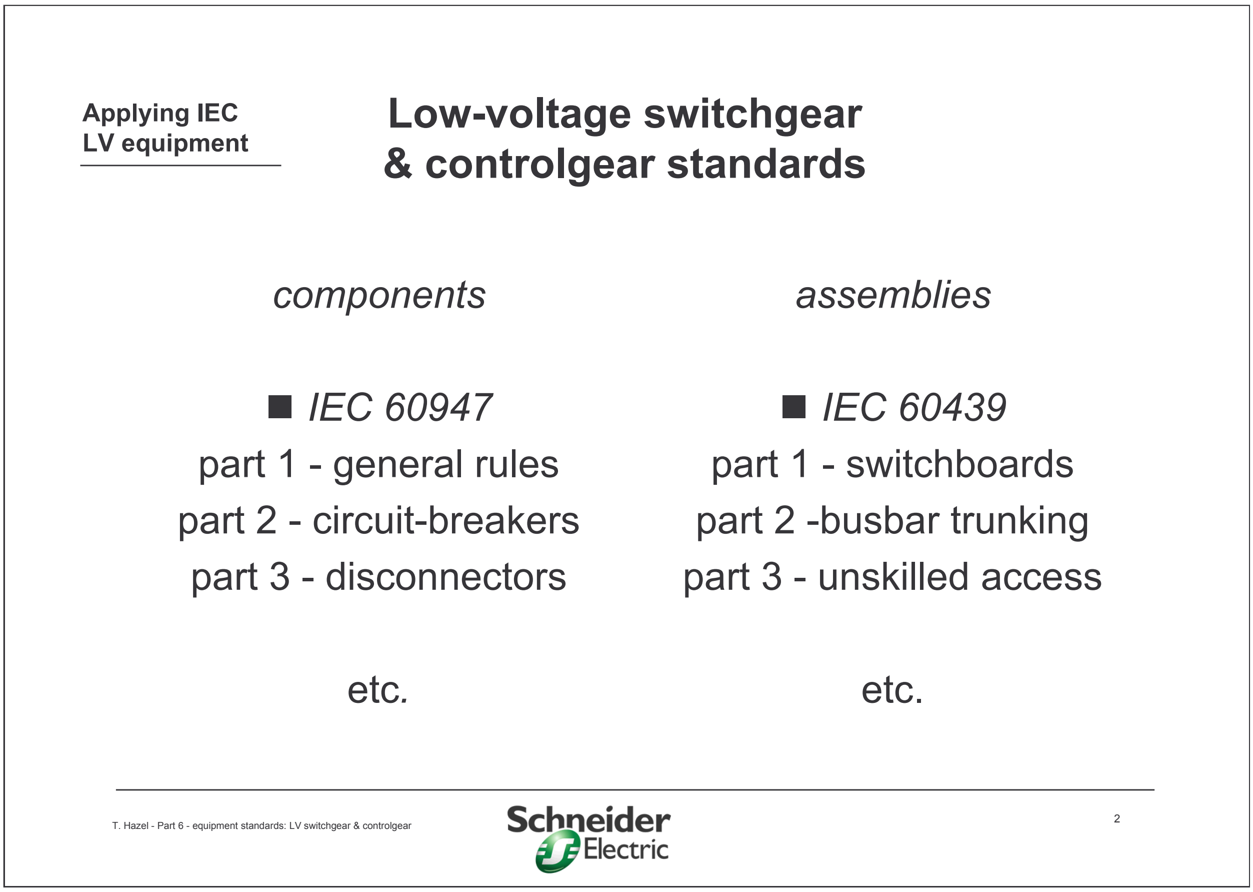
low-voltage switchgear & controlgear

Low-voltage switchgear and controlgear

Low-voltage switchgear and controlgear is present in most industrial and commercial applications. This part of the tutorial reviews several of the different options defined in the low-voltage series of standards.

switchgear and controlgear

The term switchgear and controlgear assemblies is used for all low voltage switchboards and panels. This is the same as is done in the high-voltage IEC standards discussed in part 5 of the tutorial



Low-voltage switchgear & controlgear standards

components	*assemblies*
■ *IEC 60947*	■ *IEC 60439*
part 1 - general rules	part 1 - switchboards
part 2 - circuit-breakers	part 2 -busbar trunking
part 3 - disconnectors	part 3 - unskilled access
etc.	etc.

low-voltage switchgear and controlgear

Low-voltage switchgear and controlgear are largely covered by 2 standards each of which has several parts. These are *IEC60947 low-voltage switchgear and controlgear* which deals with the components and *IEC60439 low-voltage switchgear and controlgear assemblies* which considers the equipment in which the components are installed. These standards consist of several hundred pages each.

For assemblies, all references hereafter refer to IEC60439-1. The 4th edition of this standard was issued in 1999 incorporating all the changes that had been included in amendments.

The general term *assembly* will be used for all equipment such as panel boards, switchboards, etc. A *functional unit* in an assembly is a motor starter, feeder, incoming circuit, or bus-tie circuit.

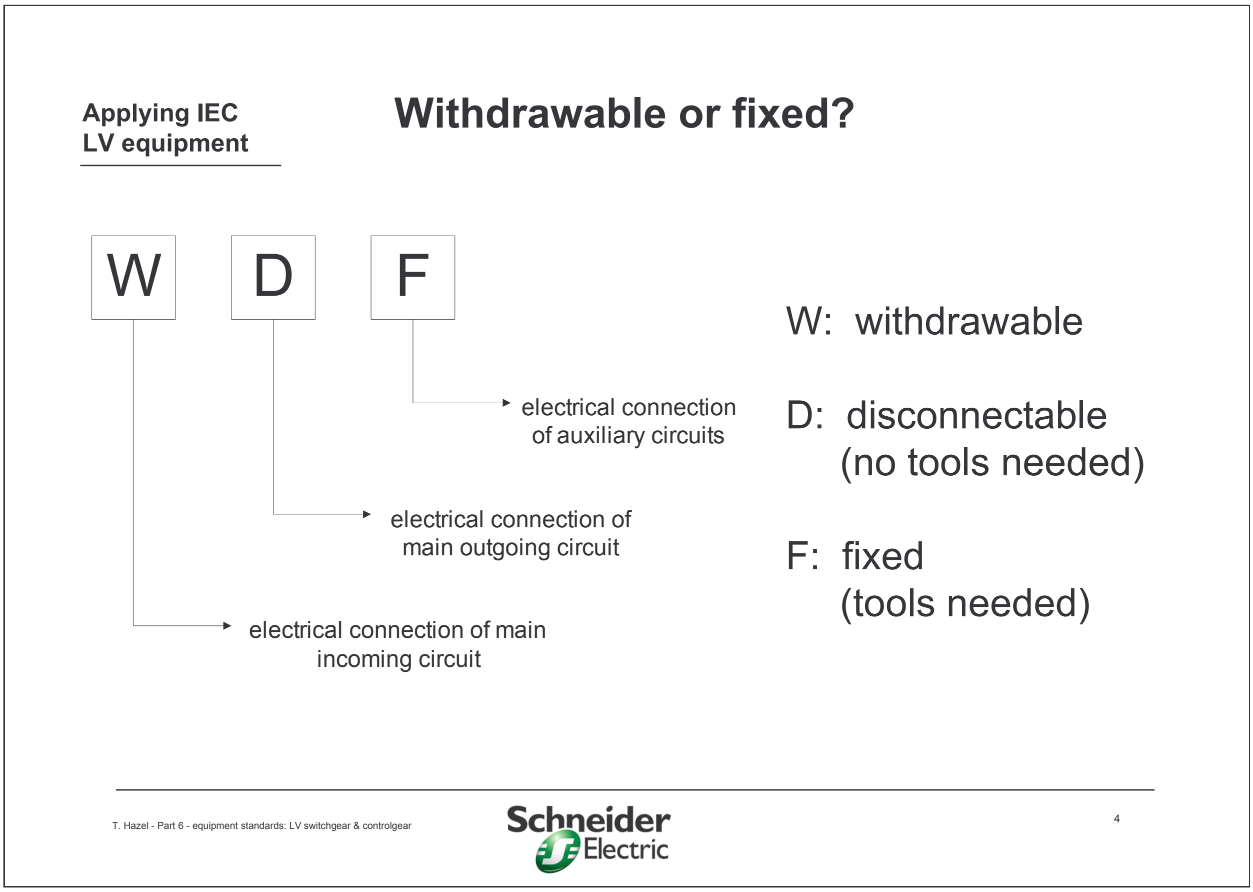
IEC60439 - one standard for all low-voltage assemblies

Main switchgear

Panel board

Since there is only one IEC standard for all low-voltage assemblies, it is by specifying the different options defined in the standard that the type of gear is chosen. The options have an important impact on the availability of the gear, ease of maintenance, and shut-down requirements for extensions, etc.

The "Main switchgear" shown is typical for industrial applications and is a fully withdrawable motor control center with 2 incoming air circuit-breakers. The "Panel board" is typical for commercial buildings and has fixed outgoing molded case and miniature circuit-breakers and withdrawable incoming and bus-tie air circuit-breakers.



Applying IEC LV equipment

Withdrawable or fixed?

W
D
F
electrical connection of auxiliary circuits
electrical connection of main outgoing circuit
electrical connection of main incoming circuit

W: withdrawable

D: disconnectable
(no tools needed)

F: fixed
(tools needed)

types of electrical connections

There has been much confusion in the past with terms such as *withdrawable*, and *semi-withdrawable*. Sub-clause 7.11 defines a 3 letter code to eliminate this confusion.

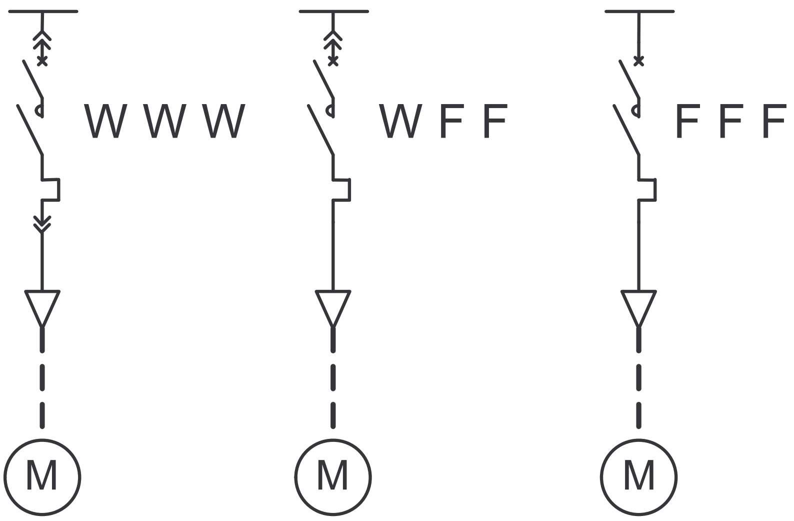
For each electrical connection there is a choice of 3 letters:

☐ F: fixed connection requiring a tool for disconnection.

☐ D: disconnectable connection requiring manual operation but no tools. In the disconnected position the removable part is not required to be mechanically attached to the assembly, an example being a plug-in molded case circuit-breaker.

☐ W: withdrawable connection where the connection is made by bringing the functional unit into the connected or disconnected situation. In the disconnected position the removable part remains mechanically attached to the assembly.

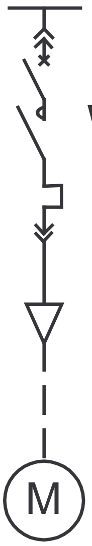
Examples of starter types



For industrial applications where down time is to be kept to a minimum, a W W W configuration is recommended. This enables motors starters to be removed and replaced without having to disconnect any power or control cables. In addition to reducing the down time this eliminates the possibility of incorrect reconnection of cables.

Applying IEC LV equipment

Is W W W enough?



Can controlgear be changed without a shutdown?

Can spare spaces be connected to control system without shutdown?

Process MCCs are controlled from the DCS via hard wired connections or communciations systems. When intelligent or communicating MCCs are used, ensure that the control system has the same flexibility as the power portion.

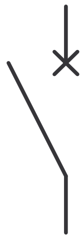
This means being able to:

☐ withdraw starters

☐ change starters

☐ add starters in equipped spare spaces.

Low-voltage circuit-breakers



MCCB or ACB?

- Standard does not differentiate between ACB and MCCB

- category A: no time delay (MCCB= category A)

  category B: time delay (ACB = category B)

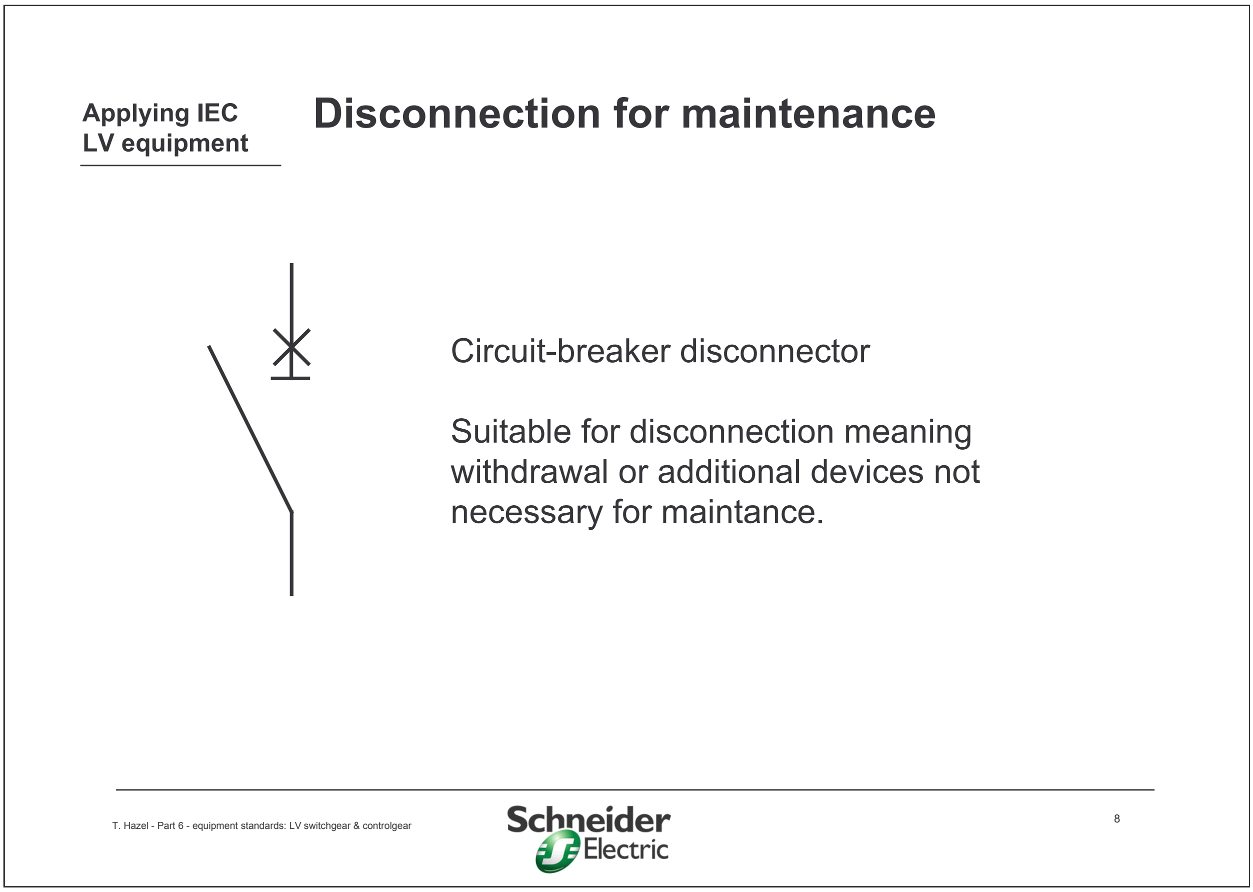
low-voltage circuit-breakers

IEC60947-2 cancels and replaces IEC157. The following are some aspects where confusion can occur.

molded case and power circuit-breakers

The IEC standards (and the symbols) do not make any distinction between molded case circuit-breakers (MCCB) and power circuit-breakers commonly called air circuit-breakers (ACB) or metal frame circuit-breakers. For IEC an air circuit-breaker is one in which the contacts open and close in air at atmospheric pressure as opposed to a vacuum circuit-breaker or a gas circuit-breaker. Since for both ACBs and MCCBs the contacts are in air at atmospheric pressure, both types of circuit-breakers are considered air-break and clients may end up not getting what they thought they had specified.

Generally MCCBs are category A meaning no short-circuit trip delay. ACBs are category B meaning provision of a short-circuit time delay. Some large MCCBs are category B however.



Applying IEC
LV equipment

Disconnection for maintenance

Circuit-breaker disconnector

Suitable for disconnection meaning withdrawal or additional devices not necessary for maintance.

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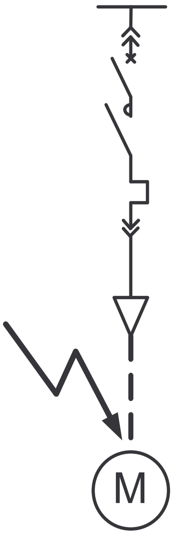
disconnecting function

Additional impulse tests using higher voltages are conducted with the circuit-breaker in the open position to ensure that it is suitable for isolation. Circuit-breakers having this function have the symbol shown above and can be used to isolate a circuit for maintenance purposes.

Applying IEC
LV equipment

Motor starter coordination



- Type 1: destruction of contactor and thermal relay permitted
- Type 2: circuit-breaker protects contactor and thermal relay

type 2 normally specified
(check inrush current)

Schneider Electric

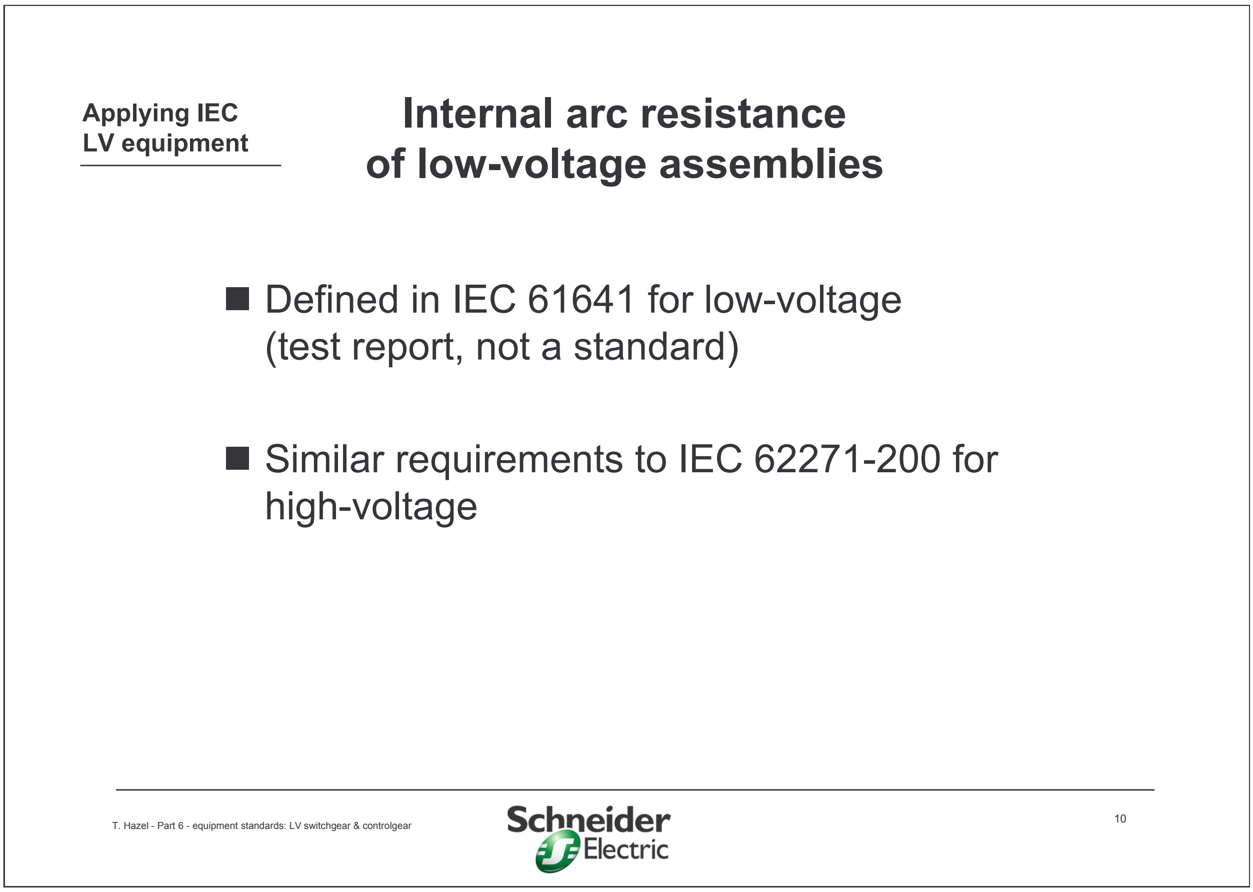
motor starter coordination types 1 and 2

Motor starters often use a combination of a molded case circuit-breaker with a magnetic trip unit, a contactor, and a thermal relay. The circuit-breaker will eliminate short-circuits and the thermal relay will protect the motor from overloads.. Sub-clause 7.2.5.1 *IEC60947-4-1 low-voltage switchgear and controlgear part 4 contactors and motor-starters section 1 – electromechanical contactors and motor starters* defines 2 types of coordination between the circuit-breaker and the other devices in the starter:

☐ type 1: The contactor and/or thermal relay may be destroyed by the let-through energy

☐ type 2: The contactor and overload relay will not be damaged. Some sticking of contactor contacts is allowed.

For industrial applications type 2 coordination should normally be specified. Since the let-through energy depends on the maximum available short-circuit current, this should also be given in the specification, for example *type 2 coordination at 65kA*.



Applying IEC
LV equipment

Internal arc resistance of low-voltage assemblies

- Defined in IEC 61641 for low-voltage (test report, not a standard)
- Similar requirements to IEC 62271-200 for high-voltage

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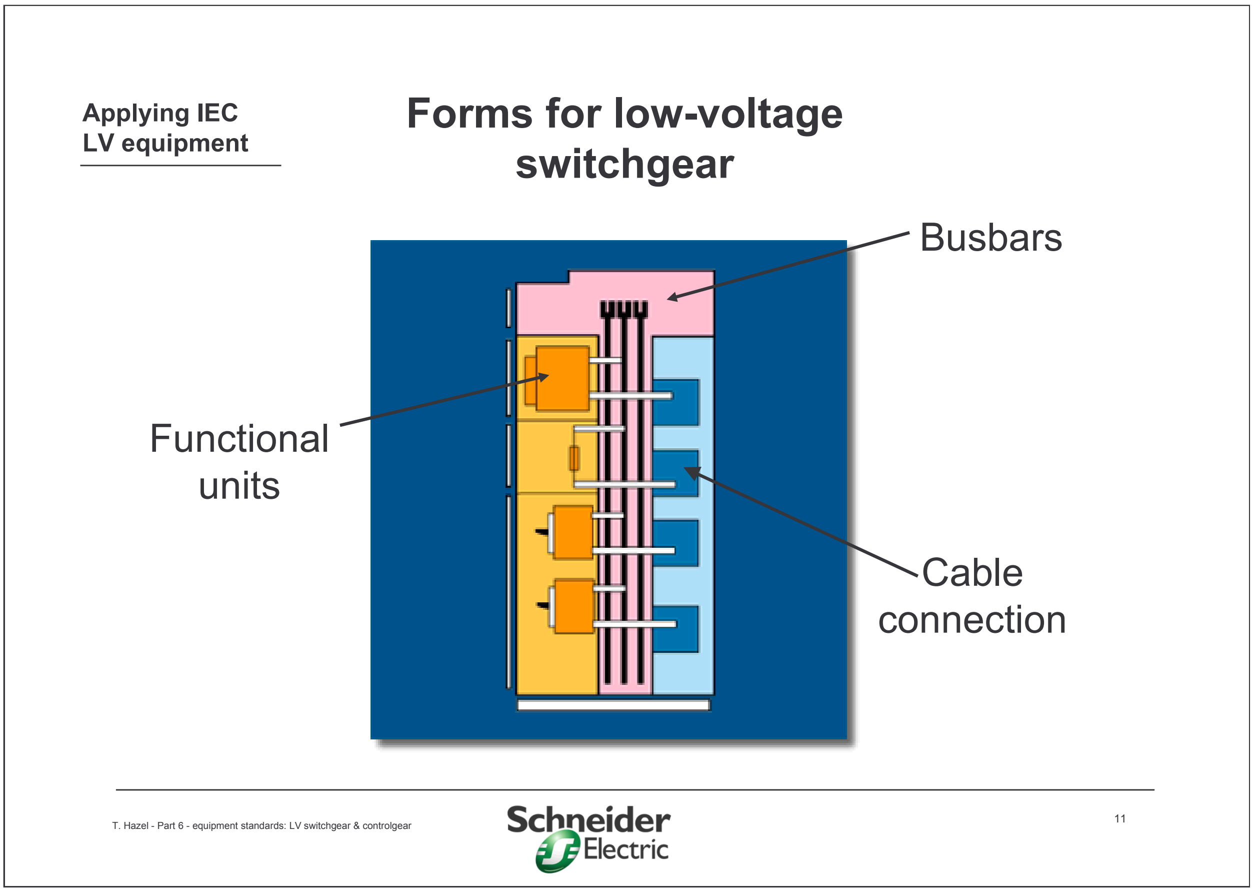
internal arc resistance testing

IEC 61641 states that "The sole purpose of this test is to assess the ability of the assembly to limit the risk of personal injury resulting from an internal arcing fault." It is not a compulsory test nor a type test. It is a special test subject to agreement between the manufacturer and user.

The same criteria concerning doors flying open, flaps etc. flying off, holes appearing, ignition of indicators, and earthing connections as defined in IEC62271-200 are used.



Applying IEC LV equipment

Forms for low-voltage switchgear

Busbars

Functional units

Cable connection

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switchgear form

The availability of an assembly is not just related to its reliability but also to the manner in which routine maintenance and modifications can be carried out. The form of an assembly as defined below is directly related to this.

The division of assemblies into separate compartments is designated by a form number as per sub-clause 7.7 of IEC60439-1. There are 4 basic forms which are defined below.

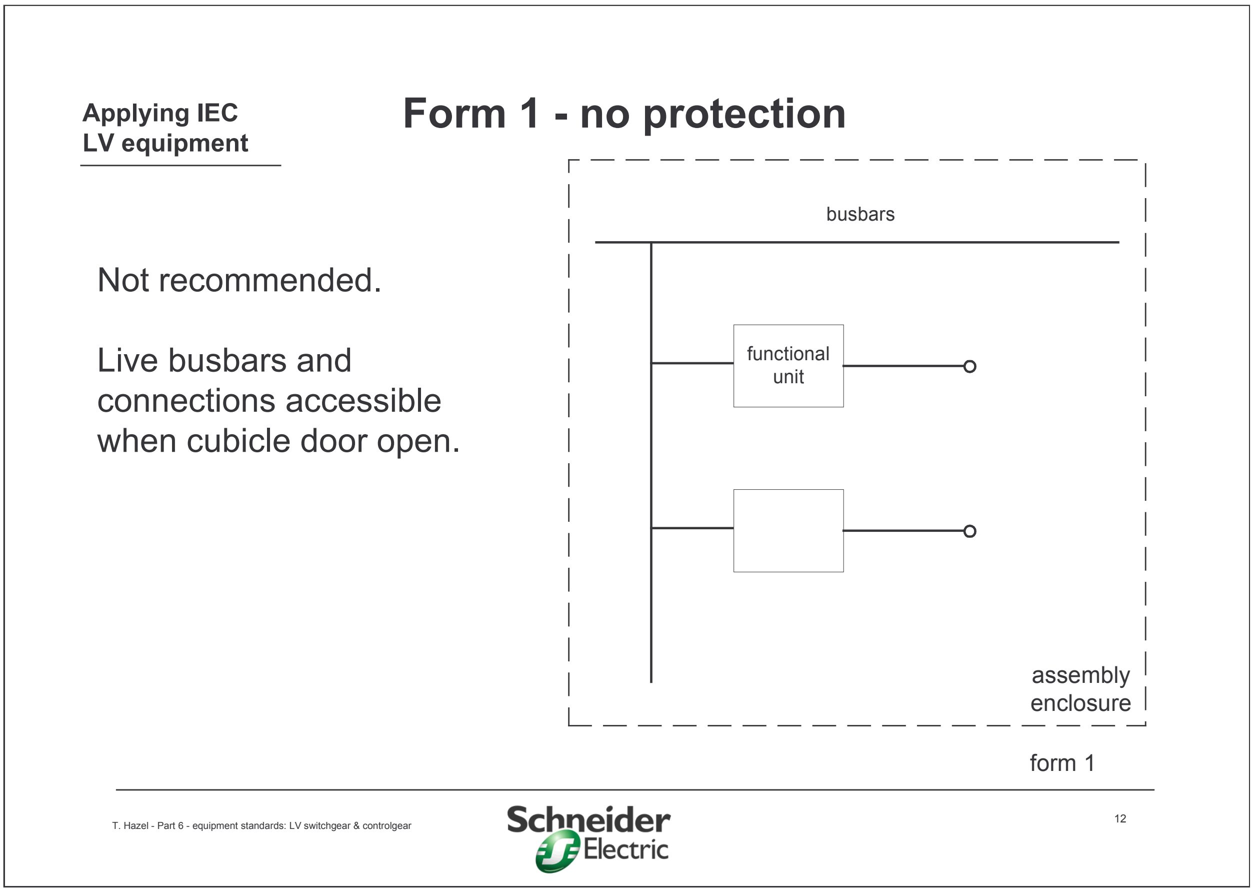
☐ form 1: no separation

☐ form 2 (a & b): separation of busbars from functional units

☐ form 3 (a & b): same as form 2 and separation of all functional units from one another

☐ form 4 (a & b): same as form 3 but including terminals of the functional unit.

The difference between the a and b versions is the separation between the functional unit and its own terminals.



Applying IEC
LV equipment

Form 1 - no protection

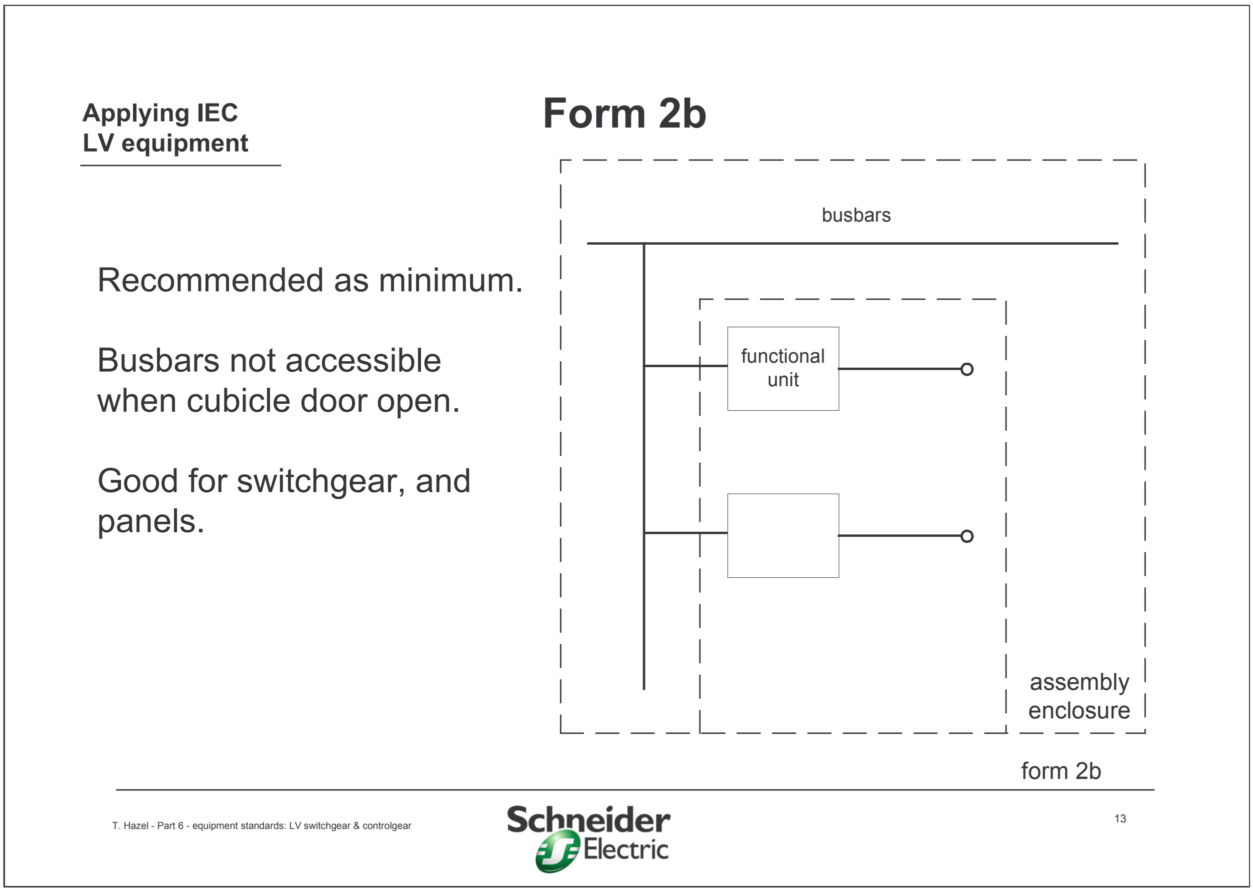
Not recommended.

Live busbars and connections accessible when cubicle door open.

use of forms for industrial applications

Form 1 presents a safety hazard. When a cubicle door is opened access to bare conductors such as main busbars is possible. Assemblies having form 1 should be de-energized prior to any maintenance work or modifications since there is no protection against direct contact within the assembly.

Form 1 should not be used except in very special cases. If form 1 is used for specially designed equipment there should be warning signs on the equipment enclosure to prevent accidental contact with live parts when opening the enclosure doors or panels.



Form 2b

Recommended as minimum.

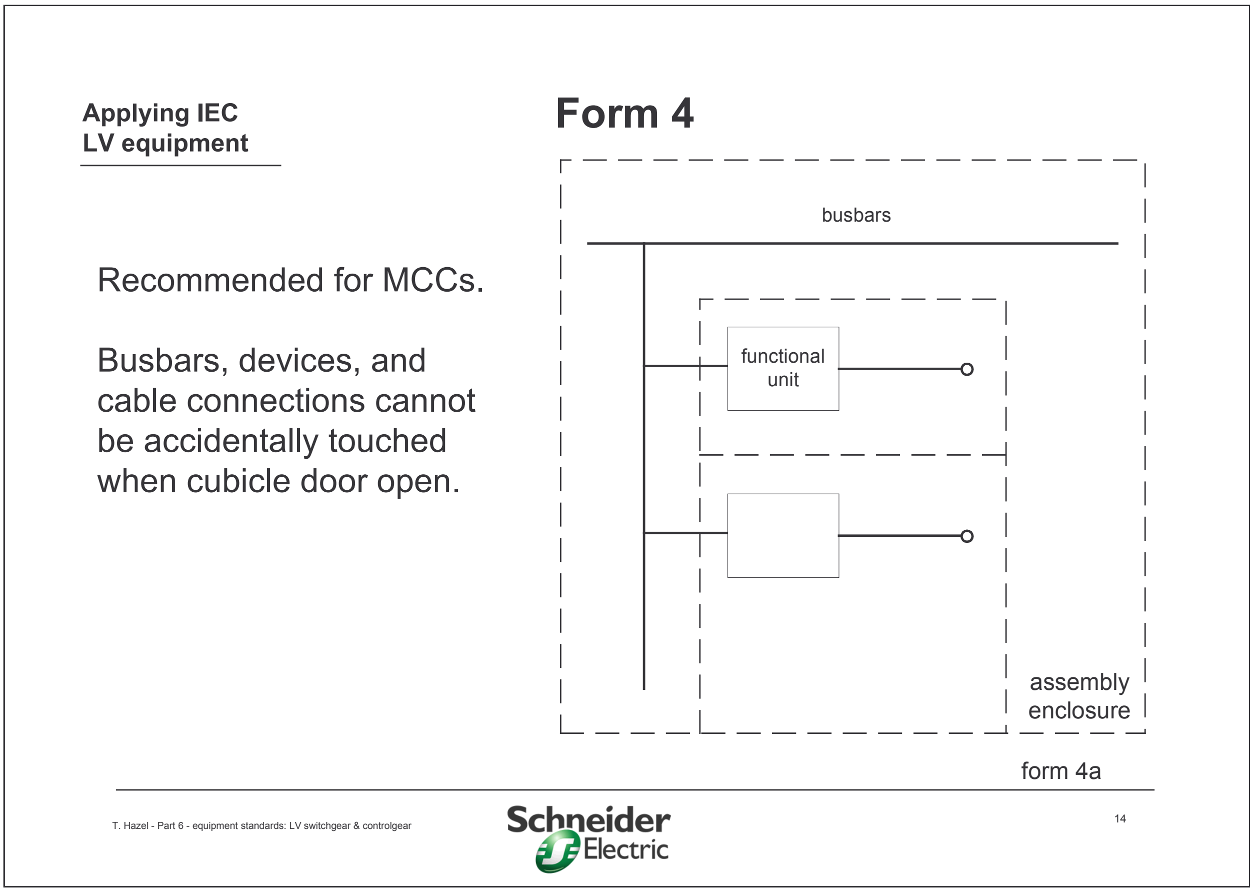
Busbars not accessible when cubicle door open.

Good for switchgear, and panels.

form 2b

form 2 as a minimum requirement

Form 2b should be specified as a minimum requirement for any assembly. Upon opening cubicle doors accidental contact with busbars is prevented. Since most devices such as molded case circuit-breakers, ACBs etc. have class II insulation and often IP2X terminals, accidental contact is unlikely. Should work have to be carried out with the equipment energized, it can be done safely downstream of disconnecting circuit-breakers.



Form 4

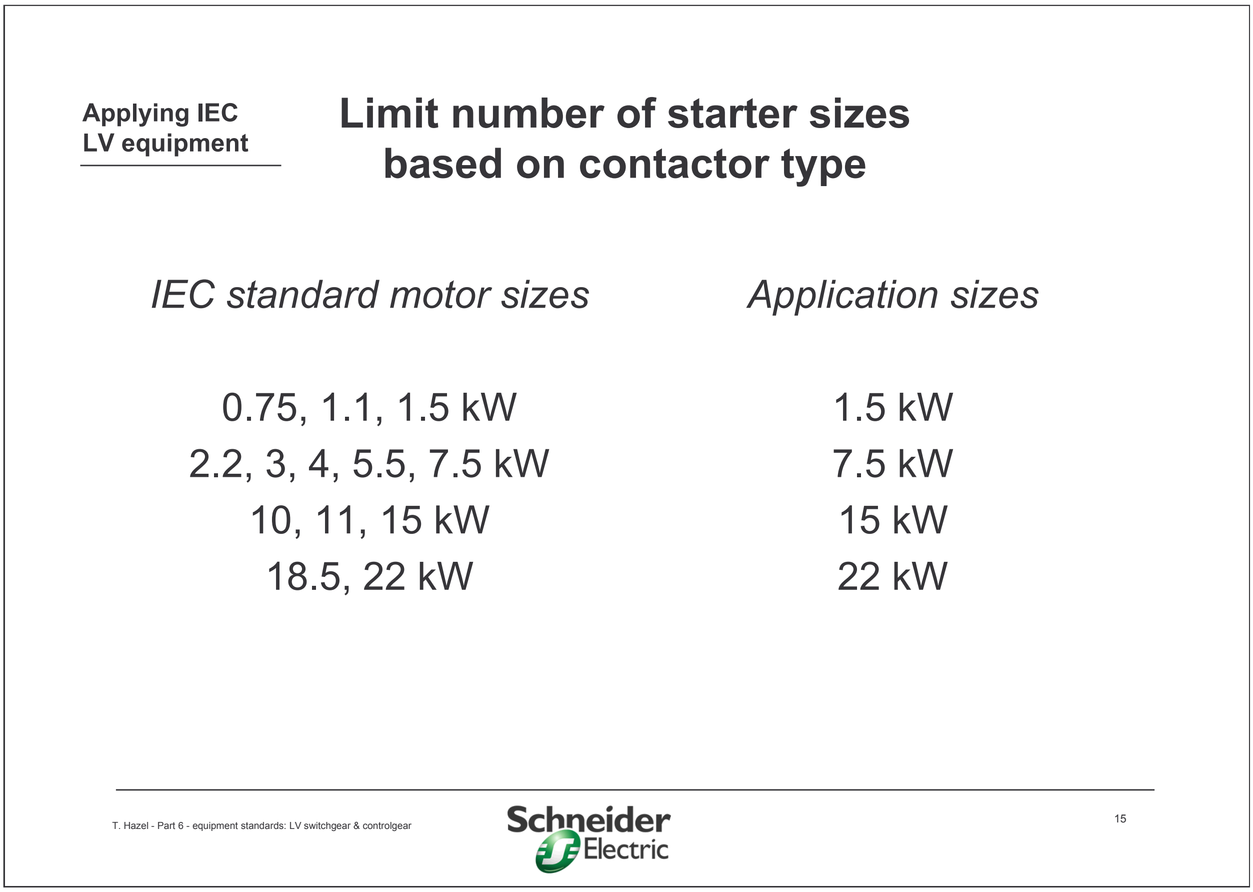
Recommended for MCCs.

Busbars, devices, and cable connections cannot be accidentally touched when cubicle door open.

form 4 for process MCCs

For important assemblies such as process motor control centers, or panels supplying critical loads, form 4a is recommended. This allows individual circuits and their cabling to be modified, added, removed, or tested without de-energization of any other circuit. Form 3 is not sufficient for this since cable terminals are not separated from one another and there is a risk of direct contact with an adjacent energized cable.

Control equipment used with form 4 switchgear should be designed so that equipment such as motor starters can be added or removed without any interruptions in process control. This requires that on-line reconfiguration of the control system be possible.



Limit number of starter sizes based on contactor type

IEC standard motor sizes	*Application sizes*
0.75, 1.1, 1.5 kW	1.5 kW
2.2, 3, 4, 5.5, 7.5 kW	7.5 kW
10, 11, 15 kW	15 kW
18.5, 22 kW	22 kW

starter sizes for small motors

IEC manufacturers generally have several different motor starters up to 11kW. They are often not the same size and cannot be readily exchanged. Many engineers have had the unpleasant surprise at the job site of having to make large changes a motor control center due to some changes in the rated power of small motors. It is recommended that the customer and manufacturer agree on limiting the number of different sizes of starters by having each one cover a range of smaller motors.